Evaluation of the Effects of Brewery Effluents Disposal on Public Water Bodies in Nigeria

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ABSTRACT

Investigation of the effect of brewery industries effluents disposal on their surrounding surface and ground waters were carried out. Four Brewery industries in two locations in Benin, Ibadan and Lagos were selected for the study. The water samples were subjected to laboratory analysis to determine variation in physical, chemical and elemental components of the samples. The results of the groundwater parameters examined tended to fall within the Federal Ministry of Environment and Urban Development (FMEUD) and World Health Organization (WHO) recommended standard values. The results of the surface waters when compared with National (FMEUD) and International (WHO) permissible limits for aquatic ecosystems indicated that the physicochemical condition of the streams located at Agidingbi, Alaka, Osu and Ossomora have been influenced by the various pollutants.

Keywords: brewery effluents, groundwaters, physicochemical, stream, surface waters

INTRODUCTION

Surface and ground waters are important sources of drinking water. Surface waters offer economic support for agricultural irrigation process and cooling waters for power plants, chemical, steel, breweries, mining and other industrial operation. Many people, particularly the rural population, get their household water supplies from underground sources. Groundwater is also used for a large proportion of industrial water needs. Both surface and ground waters are highly susceptible to contamination. Surface water has been the most convenient sewer for industries and municipalities. One of the pollutants in particular, oxygen-demanding waste, has been such a pervasive surface water problem as they affect fish and other aquatic life (USEPA 1992). The pathogens, nutrients, heavy metals and volatile organic compounds adversely affect human and other living things. Unlike surface water, groundwater contamination is through percolation and migration of pollutants by way of soil into it; but usually undetected until it is used.

Industries such as food and beverages, breweries, metal works, petroleum refinery, soap and detergent, textiles, paints, chemicals and plastics, etc. produce various effluents that are discharged into the environment. The pollutants from these effluents have been identified as being responsible for major health and environmental problems such as motor neuron disease (Iwan and et al. 1994; Ademuga et al. 2006), reproduction disorders (Mantovani 1993) and cardiovascular diseases (Clayton 1976). In 1965, cases of minamata disease were reported in Japan (Ut Jun, 1989, 1992). The disease affects the field of vision, hearing and speech. In extreme cases causing insanity, paralysis, coma and death (Ut Jun 1969) as a result of pollution of water by the release of methyl mercury from industrial effluents from a chemical factory. In Nigeria there were cases of outbreak of mercury poisoning when a number of people ate bread made from wheat which had been treated with alkyl mercury as a fungicide (Ademoro 1996).

Heavily populated cities like Lagos, Port Harcourt, Ibadan, Kaduna, Benin, Kano, etc. are mostly feeling the effect of pollution from industrial effluent discharged into the public water body. Although most of the multinational companies in Lagos and Port Harcourt have effluent pretreatment plants, they do not have primary, secondary and tertiary treatment facilities and most often the effluent discharged from these plants do not meet the Federal Ministry of Environment and Urban Development (FMEUD); or even the in-house effluent limits.

With the ever increasing pressure for both statutory and environmental source to reduce pollution to a minimum possible, it has become more necessary for active treatment of various brewery effluents before discharge into any surrounding water body. In the light of this background the objective of this study was to evaluate the effects of brewery effluents disposal on the public water body by the three major brewery industries in Nigeria at their different locations.

MATERIALS AND METHODS

Study areas

The study areas cover the surrounding streams of four major brewery industries: Nigeria Brewery Plc located near Alaka stream in Ijora, Lagos and the Ibadan branch located near Osu stream, Alaka in the North east part of Ibadan, Guinness Nigeria Plc located near Agidingbi stream in Ikeja, Lagos and Benin branch located near Osu stream along Warri-Sapele road, Benin. The areas covered by these brewery industries are within different ecosystems.

Sample preservation and storage

Samples were collected at different locations along the course of the streams. The choice of locations was based on the ease of access to the streams. A total of six samples were collected at upstream, effluent stream intersection and downstream during dry and wet season over a period of two years. The sampling stations from each of the stream course are as indicated in the study area maps (Fig. 1). The samples were taken in acid washed 500 ml
polythene bags. Prior to collection, 2 ml of 40 mg/l mercuric chloride was added to each sample bag as a biocidal preservative. Samples collected were filled completely to eliminate air and hence inhibit aerobic biological action. At least two replicate samples were taken each time. For trace metal analyses, samples were collected in 50 cm³ plastic bottles which had been previously sealed in 10% nitric acid for two days and thoroughly rinsed with distilled water. About two drops (3 ml analytical grade nitric acid per litre of sample) of nitric acid (pH < 2.0) were added to each sample, sealed in double polyethylene bags, kept in ice chests and taken to the laboratory where they were further preserved in a refrigerator before analysis. This was to ensure stability of the samples, maintain the oxidation state of the element and prevent metals from adhering to the walls of the container.

Water parameters (pH, conductivity, temperature and dissolved oxygen) were measured in situ. Samples for dissolved oxygen (DO) were collected in 300 ml Winkler bottles and preserved with 2 ml manganese sulphate and 2 ml of 1% alkaline iodide azide of sodium solution. Samples for nutrients (nitrate and nitrite) were stored frozen at 4°C. Samples for biochemical oxygen demand (BOD) were collected in 250 ml brown BOD bottles and sealed to exclude air bubbles and then incubated in the laboratory for five days before analysis.

Method of analysis

The analyses were carried out using different standard methods to obtain parameters in Tables 1 and 2. For physico-chemical analyses, a standard method of effluent; temperature (thermometer); pH (WTW pH 90 electronic meter; sensitivity ± 1.0‰); dissolved oxygen (Winkler titration); total suspended solids (TSS) spectrophotometric determination according to IAC; Chemical Oxygen Demand (COD) potassium dichromate oxidation and titrations; Biochemical Oxygen Demand (BOD) was measured as the difference between initial oxygen concentration in sample and concentration after 5 days incubation in BO bottles at 20°C (APHA 1995). Zn, Mn, Fe, Cu, and Cr concentrations were determined using an Atomic Absorption Spectrophotometer, AAS model 2380.

All chemicals used were of analytical grade procured from BDH Chemicals Ltd., England and deionised water was used throughout the experimentation to ensure acceptable data quality. The methods of analysis are as specified in Standard Methods for the Examination of Water and Wastewaters (APHA 1995). The results of physico-chemical analysis of the surface and ground water samples are presented in Tables 1 and 2. These include the mean, standard deviation of values of each parameter during the period of sampling aligned with the goals of high standards, World Health Organization (WHO) recommended standards and other regulatory standards. The results are supported with the use of statistical analysis.

RESULTS AND DISCUSSION

The results of physico-chemical analysis of the surface and ground water samples are presented in Tables 1 and 2. These include the mean, standard deviation of values of each parameter during the period of sampling. Table 1 shows that the water is of acceptable quality, with the exception of some parameters such as pH, conductivity, and dissolved oxygen which are slightly higher than the WHO and FMEUD standards. The results are supported with the use of statistical analysis.

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### Table 1: The mean values of physico-chemical and metals analysis of selected streams used as sewer by some breweries in Benin, Ibadan and Lagos.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Ossimona Stream, Benin</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Range</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Range</th>
<th>PM En</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.87</td>
<td>0.65</td>
<td>1.31</td>
<td>6.27</td>
<td>0.057</td>
<td>0.01</td>
<td>6.9</td>
<td>6.5-8.5</td>
<td></td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>26.52</td>
<td>0.36</td>
<td>0.9</td>
<td>26.4</td>
<td>0.778</td>
<td>1.1</td>
<td>&lt;40</td>
<td>&lt;40</td>
<td></td>
</tr>
<tr>
<td>Conductivity (us/cm)</td>
<td>13.17</td>
<td>0.42</td>
<td>0.59</td>
<td>11.2</td>
<td>0.431</td>
<td>0.9</td>
<td>400</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Turbidity (FTU)</td>
<td>6.667</td>
<td>0.35</td>
<td>0.5</td>
<td>5.933</td>
<td>0.441</td>
<td>0.2</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Acidity (mg/l)</td>
<td>3.55</td>
<td>0.13</td>
<td>0.3</td>
<td>3.867</td>
<td>0.636</td>
<td>1</td>
<td>1000</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Alkalinity (mg/l)</td>
<td>260.8</td>
<td>0.799</td>
<td>3.39</td>
<td>265.5</td>
<td>7.566</td>
<td>10.7</td>
<td>500</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Total hardness (mg/l) CaCO₃</td>
<td>147.4</td>
<td>1.237</td>
<td>10.5</td>
<td>148.3</td>
<td>6.329</td>
<td>10.16</td>
<td>500</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Total Solids (mg/l)</td>
<td>502.2</td>
<td>7.35</td>
<td>11</td>
<td>492.2</td>
<td>5.551</td>
<td>106.92</td>
<td>1000</td>
<td>1000</td>
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<tr>
<td>Total Suspended Solids (mg/l)</td>
<td>122.1</td>
<td>0.368</td>
<td>1.76</td>
<td>123.4</td>
<td>0.665</td>
<td>3.5</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Total Dissolved Solids (mg/l)</td>
<td>562.2</td>
<td>2.341</td>
<td>5.8</td>
<td>567.2</td>
<td>8.351</td>
<td>17.56</td>
<td>2000</td>
<td>1500</td>
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<tr>
<td>Biochemical Oxygen Demand (mg/l)</td>
<td>51.55</td>
<td>0.431</td>
<td>1.57</td>
<td>51.27</td>
<td>1.909</td>
<td>2.7</td>
<td>50</td>
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<td>Chemical Oxygen Demand (mg/l)</td>
<td>91.69</td>
<td>0.156</td>
<td>2.24</td>
<td>85.2</td>
<td>3.231</td>
<td>4.57</td>
<td>80.1</td>
<td>80</td>
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<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>1.36</td>
<td>0.532</td>
<td>1.41</td>
<td>1.23</td>
<td>0.177</td>
<td>1.19</td>
<td>7.5</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>73.35</td>
<td>2.128</td>
<td>13.4</td>
<td>70.83</td>
<td>1.188</td>
<td>3.57</td>
<td>600</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>2.057</td>
<td>0.099</td>
<td>0.21</td>
<td>1.77</td>
<td>0.247</td>
<td>0.35</td>
<td>20</td>
<td>10</td>
<td></td>
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<tr>
<td>Sulphate (mg/l)</td>
<td>4.117</td>
<td>0.325</td>
<td>0.45</td>
<td>5.043</td>
<td>0.064</td>
<td>0.16</td>
<td>500</td>
<td>400</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Metals</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Range</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Range</th>
<th>PM En</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc (mg/l)</td>
<td>1.847</td>
<td>0.142</td>
<td>0.17</td>
<td>1.7</td>
<td>0.141</td>
<td>0.2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Manganese (mg/l)</td>
<td>2DL</td>
<td>0.025</td>
<td>&lt;DL</td>
<td>0.025</td>
<td>0.014</td>
<td>0.03</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Iron (mg/l)</td>
<td>1.386</td>
<td>0.092</td>
<td>0.42</td>
<td>1.133</td>
<td>0.035</td>
<td>0.11</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Copper (mg/l)</td>
<td>0.176</td>
<td>0.008</td>
<td>0.1</td>
<td>0.121</td>
<td>0.016</td>
<td>0.022</td>
<td>&lt;1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Chromium (mg/l)</td>
<td>0.027</td>
<td>0.007</td>
<td>0.01</td>
<td>0.02</td>
<td>0.007</td>
<td>0.01</td>
<td>&lt;1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*BDL = Below Detection Level

The mean COD concentration at Ossimona stream indicated that the brewery effluents in these areas are highly polluted with both oxidizable organic and inorganic pollutants. Also the low Dissolved Oxygen (DO) concentration could be ascribed to waste discharges high in organic matter and nutrient along the course of the streams.

Biochemical Oxygen Demand (BOD) concentration ranged between 41.82 and 51.55 mg/l for surface waters. The lowest value is that of Agidingbri stream, Lagos with 41.82 mg/l while the highest is 51.55 mg/l for Ossimona stream, Benin. The mean high BOD concentrations in these public water bodies is an indication of high concentration of biodegradable organic substances. Also the increase in concentration of BOD within the study areas could be related to effluent high in degradable organic matter from brewery and unregulated domestic dumpsites along the course of the streams in Benin and Ibadan.

The locational variation in concentration of trace metals namely; iron, manganese, zinc, copper and chromium in the surface waters and groundwaters for the period of study are presented in Tables 1 and 2, respectively. Iron was dominant in all the water samples with Ossimona stream, Benin having the highest value of 1.383 mg/l and Agidingbri stream, Lagos having the least value of 0.433 mg/l. The values are well above the permissible level of 0.3 mg/l for iron (Fe). The variations and high iron concentration across study areas could be as a result of anthropogenic inputs, as also demonstrated in the result of Valdes et al. (2005). Metals, namely Mn, Cu, Zn and Cr have values much lower than WHO and PHEUDD permissible limits, in some study areas like Agidingbri river, Lagos and Ossimona stream, Benin manganese concentrations were either low or below detection limit of the instrument. However, because a metal concentration in the aquatic environment is low and considered to be naturally occurring does not mean that the concentration could not cause adverse ecological effects (USEPA 1992; Kordari and Davies 2004; Ademugbe et al., 2007). The presence of one metal can significantly affect the impact that another metal may have on an organism. The effect can be synergistic or antagonistic (Eisler 1993).
The chloride concentrations in the study areas ranged 70.09 to 75.08 mg/l with a mean value of 70.83 mg/l for Alaka stream, Lagos; a mean value of 70.83 mg/l for Ona stream, Ibadan. Chloride concentration in Osioma stream, Benin is 73.35 mg/l while that of Agidingbi stream Lagos is 75.08 mg/l. These values are within the acceptable limit of 250 mg/l. The chloride content of groundwater may be due to the presence of salt water intrusion especially in Lagos.

Nitrates concentrations in the study areas ranged 1.77 to 2.78 mg/l for surface waters and 0.477 to 0.756 mg/l for groundwater. The nitrate levels in both surface waters and groundwaters are within the acceptable limits of less than 10 mg/l. These findings are consistent with the established fact that nitrate levels in groundwater which exceed the WHO limits are not common (O’Neill et al. 1992; Smith and Sabone 1994; Stuart et al. 1995). High level of nitrate water may induce methaemoglobinemia in infants less than six months old (Campbell and Forbes 1994).

All sulphate values of surface waters and groundwaters within the study areas are within the acceptable limit 250 mg/l. The sulphate concentration range 4.12 to 6.90 mg/l for surface water; and 2.40 to 3.50 mg/l for groundwater.

**CONCLUSION**

This study reveals that the parameter values in all the study areas for groundwaters are below FMEUD and WHO permissible limit and classify the water as unpolluted. The surface waters are generally characterized by pH in the range within FMEUD and WHO permissible limits. The values of total suspended solids (TSS), Chemical Oxygen Demand (COD) for Ona stream, Ibadan and Osioma stream, Benin are above FMEUD and WHO permissible limits while the values for Alaka and Agidingbi streams in Lagos are low and within acceptable limits. The Biological Oxygen Demand (BOD) and trace metal iron (Fe) levels in Ona stream, Ibadan, Osioma stream, Benin, Alaka and Agidingbi streams, Lagos are above maximum permissible limits for aquatic ecosystem by FMEUD and WHO. This indicates that the physiochemical condition of the rivers have been influenced by the various pollutants. The consequence of the pollution in the study areas could lead to habitat destruction and alteration of species diversity. It is imperative therefore that breweries and other industries along the course of study streams, (Ona, Osioma, Alaka and Agidingbi) in Ibadan, Benin and Lagos should set up effective measures using the best available technology to treat their effluents before discharge to the natural receptors.

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